GEORGIA
DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

Richard E. Dunn, Director

Air Protection Branch
4244 International Parkway
Suite 120
Atlanta, Georgia 30354
404-363-7000

MEMORANDUM

June 7, 2019

To: James Boylan
Thru: Byeong-Uk Kim
From: Henian Zhang
Subject: **Modeling Analysis for Ethylene Oxide Sterigenics, Smyrna, Cobb County, GA**

GENERAL INFORMATION

As part of a review on the EPA's 2014 National Air Toxics Assessment (NATA), air dispersion modeling of ethylene oxide was conducted by the Georgia Environmental Protection Division (GA EPD) to assess the impacts of ethylene oxide emissions from sources at Sterigenics on ambient air surrounding the facility. Although this modeling is not for issuance of a permit, GA EPD adopted procedures described in GA EPD's *Guideline for Ambient Impact Assessment of Toxic Air Pollutant Emissions*[1].

This memo discusses modeling results including the procedures used to develop the dispersion modeling. Two emission scenarios were modeled. The facility's current emission release configuration sends fugitive emissions to wall fans. The facility's proposed emission release configuration collects the fugitive emissions and sends them to two stacks on the roof top. For both scenarios, the air toxic impacts from ethylene oxide was below its Acceptable Ambient Concentration (AAC) at the 15-min averaging period, but exceeded its annual AAC. Site-specific risk assessments were performed at the closest four residential areas and the modeled ground-level concentrations exceeded the annual AAC at all four residential areas. The results are summarized in the following sections of this memorandum.

INPUT DATA

1. **Meteorological Data** – Hourly meteorological data (2014 to 2018) used in this review were generated by GA EPD (http://epd.georgia.gov/air/georgia-aermet-meteorological-data). Surface measurements were obtained from the Cartersville Airport, Cartersville, GA. Upper air observations were obtained from the Atlanta Regional Airport – Falcon Field, Peachtree City, GA. These measurements were processed using the AERSURFACE (v13016), AERMINUTE (v15272), and AERMET (v18081) with the adjusted surface friction velocity option (ADJ_U*).

2. **Source Data** – Emission release parameters and emission rates were provided by the company and reviewed by the GA EPD Stationary Source Permitting Program. Two emission scenarios were modeled. The current scenario refers to the facility's current emission release configuration that sends fugitive emissions to wall fans (see Appendix A for details). In the proposed scenario, two

1 https://epd.georgia.gov/air/documents/toxics-impact-assessment-guideline

stacks on the roof top will release the fugitive emissions after collecting them (see Appendix B for details).

3. **Receptor Locations** – Discrete receptors with 25-meter intervals were placed along the property boundary. Receptors extend outwards from the fence line at 100-meter intervals on a Cartesian grid to approximately 2 km and at 250-meter intervals from approximately 2 km to approximately 5 km. Additional receptors were placed at the four closest residential areas. This domain (10 km by 10 km) is sufficient to capture the maximum impact. All receptor locations are represented in the Universal Transverse Mercator (UTM) projections, Zone 16, North American Datum 1983.

4. **Terrain Elevation** – Topography was found to be generally flat in the site vicinity. Terrain data from the USGS 1-sec National Elevation Dataset (NED) were extracted to obtain the elevations of all sources and receptors by the AERMAP terrain processor (v18081).

5. **Building Downwash** – The potential effect for building downwash was evaluated via the "Good Engineering Practice (GEP)" stack height analysis and was based on the scaled site plan submitted by Sterigenics using the BPIPPRM program (v04274). The BPIPPRM model was used to derive building dimensions for downwash assessment and the assessment of cavity-region concentrations appropriate for the AERMOD model.

AIR TOXICS ASSESSMENT

The impacts of facility-wide ethylene oxide emissions were evaluated according to the Georgia Air Toxics Guideline available at https://epd.georgia.gov/air/documents/toxics-impact-assessment-guideline. The annual and 15-minute AACs were reviewed based on U.S. EPA Integrated Risk Information System (IRIS) Risk Based Air Concentration (RBAC) and OSHA Permissible Exposure Limit (PEL) according to the Georgia Air Toxics Guideline (see Appendix C for details). The EPA NATA used a different annual AAC value (see Appendix D for details). For this assessment, GA EPD used the annual AAC derived according to the Georgia Air Toxics Guideline and took two approaches to evaluate the impacts. The first approach (described in the Georgia Air Toxics Guideline) selects the year with the highest annual modeled maximum ground-level concentrations (MGLC) from the 5-year period and uses this year in the assessment. The second approach uses the annual modeled concentrations averaged across the 5-year period. The modeled 1-hour and annual ground-level concentrations were calculated using the AERMOD dispersion model (v18081).

Analysis with the Highest 5-Year MGLCs

Table 1 summarizes the AAC levels and the MGLCs from the two modeling scenarios with the highest 5-year MGLCs. The 15-min MGLC is based on the 1-hour MGLC multiplied by a factor of 1.32. The 15-min MGLC was below its corresponding 15-min AAC. However, the annual MGLC exceeded the annual AAC. Figure 1 show the spatial distributions of ground level concentrations estimated with the current scenario and 2016 meteorological data (the year with the highest modeled MGLC). Figure 2 show the spatial distributions of MGLCs estimated with the proposed scenario and 2017 meteorological data (the year with the highest modeled MGLC). Figures 3 and 4 show close-up looks of modeling results with the current and proposed scenarios, centered at the facility with the closest four residential areas labeled. The MGLCs of the four closest residential areas are shown in Table 2. The number of

households affected by 10 times of AAC (blue lines on Figures 1 to 4) was reduced from approximately 1,000 with the current emissions scenario to approximately 600 with the proposed emissions scenario.

Table 1. Modeled Highest 5-year MGLCs from the Current and Proposed Scenarios and the Respective AACs.

Averaging period	MGLC ($\mu g/m^3$) Current Scenario*	MGLC ($\mu g/m^3$) Proposed Scenario#	AAC ($\mu g/m^3$)
Annual	1.5	0.16	0.00033
15-min	39	1.4	900

* The highest concentration over all averaging periods was modeled in 2016.
\# The highest concentration over all averaging periods was modeled in 2017.

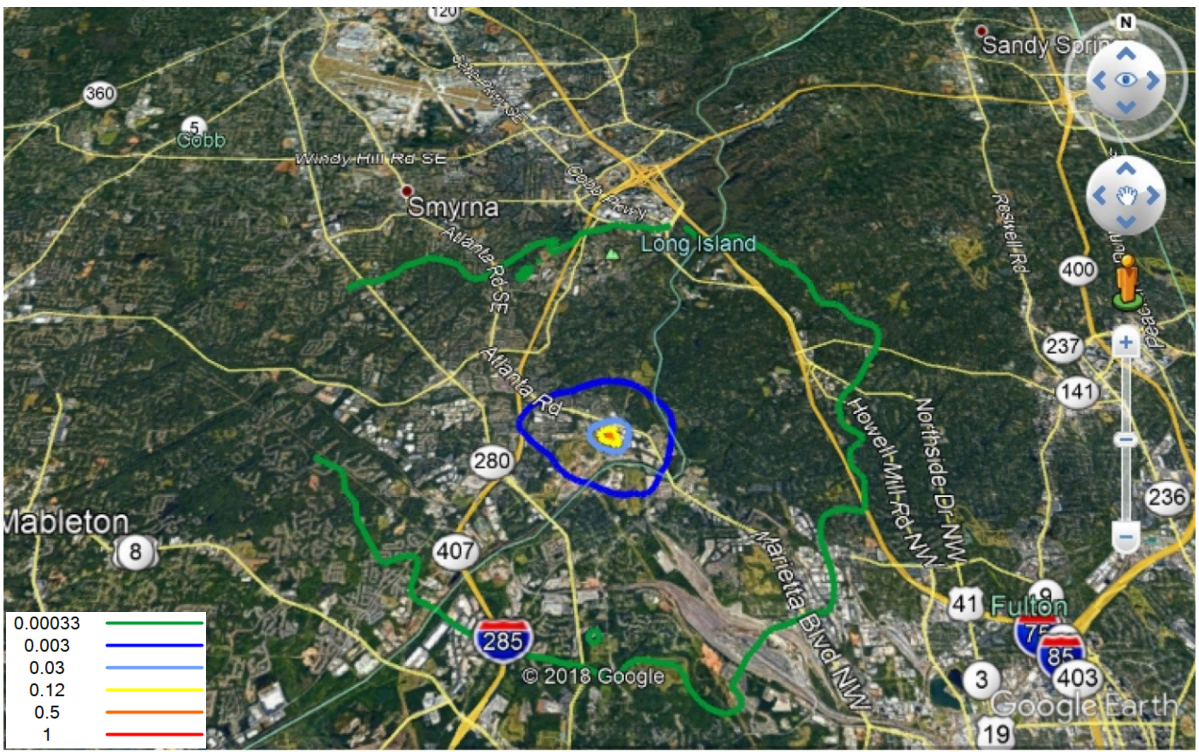

Figure 1. Contours of annual average ground-level concentrations modeled with the current emission scenario overlaid on a Google Earth map for 2016 (the year with the highest modeled MGLC).

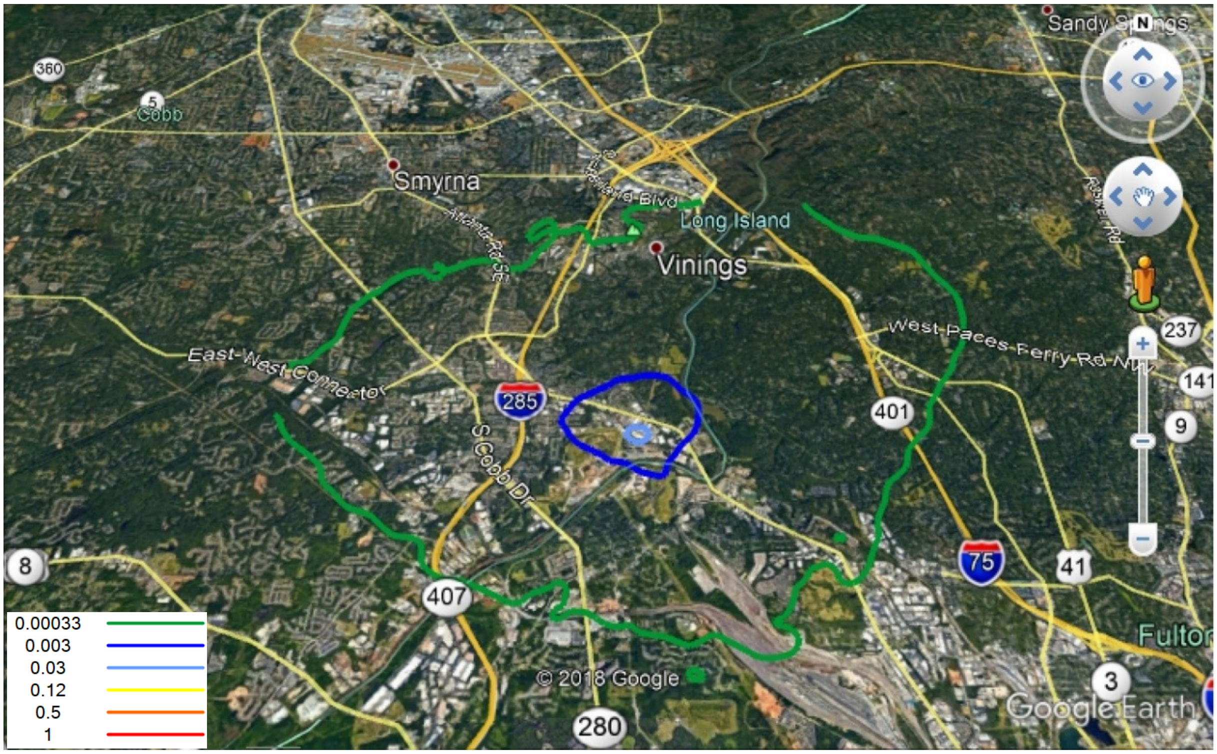

Figure 2. Contours of annual average ground-level concentrations with the proposed emission scenario overlaid on a Google Earth map for 2017 (the year with the highest modeled MGLC).

Figure 3. A close-up look of Figure 1 with the closest residential areas labeled.

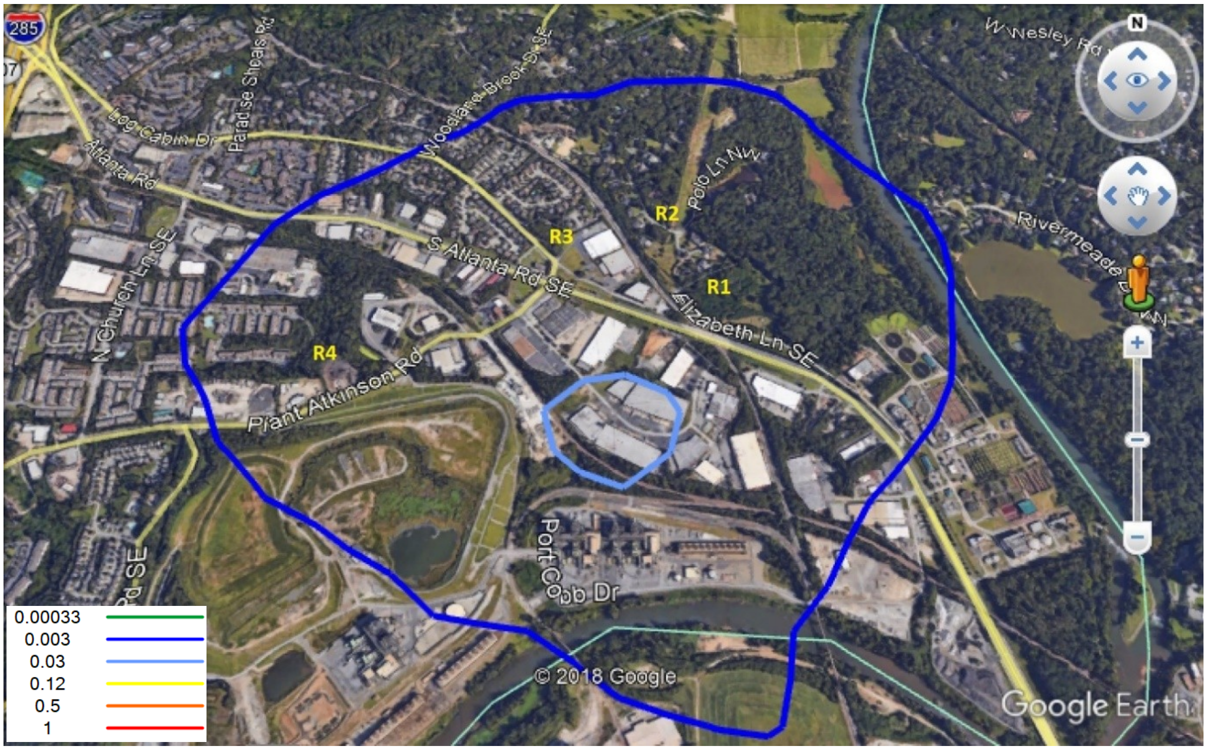

Figure 4. A close-up look of Figure 2 with the closest residential areas labeled.

Table 2. Risk Analysis for Residential Areas with Modeled Highest 5-year MGLCs.

Residential Areas	Receptor UTM Zone:16		MGLC (µg/m³)		Averaging Period	AAC (µg/m³)	Ratio of MGLC (µg/m³) to AAC (µg/m³)	
	Easting (meter)	Northing (meter)	Current Scenario*	Proposed Scenario#			Current Scenario	Proposed Scenario
R1	734,456.40	3,746,827.10	0.020	0.008	Annual	0.00033	61	24
R2	734,349.30	3,746,923.70	0.015	0.007	Annual	0.00033	45	21
R3	734,073.40	3,746,829.10	0.017	0.007	Annual	0.00033	52	21
R4	733,449.70	3,746,572.40	0.009	0.004	Annual	0.00033	27	12

* The highest concentration over all averaging periods was modeled in 2016.
# The highest concentration over all averaging periods was modeled in 2017.

Analysis with 5-Year Average Ground-level Concentrations

To further assess the impact over longer period, maximum values from the 5-year averaged ground-level concentrations from the two modeling scenarios are summarized in Table 3. Contours of modeled snnusl ground-level concentrations averaged over the 5-year period are shown in Figures 5 and 6. Figures 7 and 8 show close-up looks centered at the facility with the closest four residential areas labeled. The 5-year averaged modeled ground-level concentrations of the four closest residential areas are shown in Table 4.

Table 3. Modeled 5-year Annual Average Ground-level Concentrations from the Current and Proposed Scenarios and the Respective AAC.

Averaging period	MGLC ($\mu g/m^3$) Current Scenario*	MGLC ($\mu g/m^3$) Proposed Scenario*	AAC ($\mu g/m^3$)
Annual	1.4	0.15	0.00033

* The maximum of ground-level concentration averaged over 5 years.

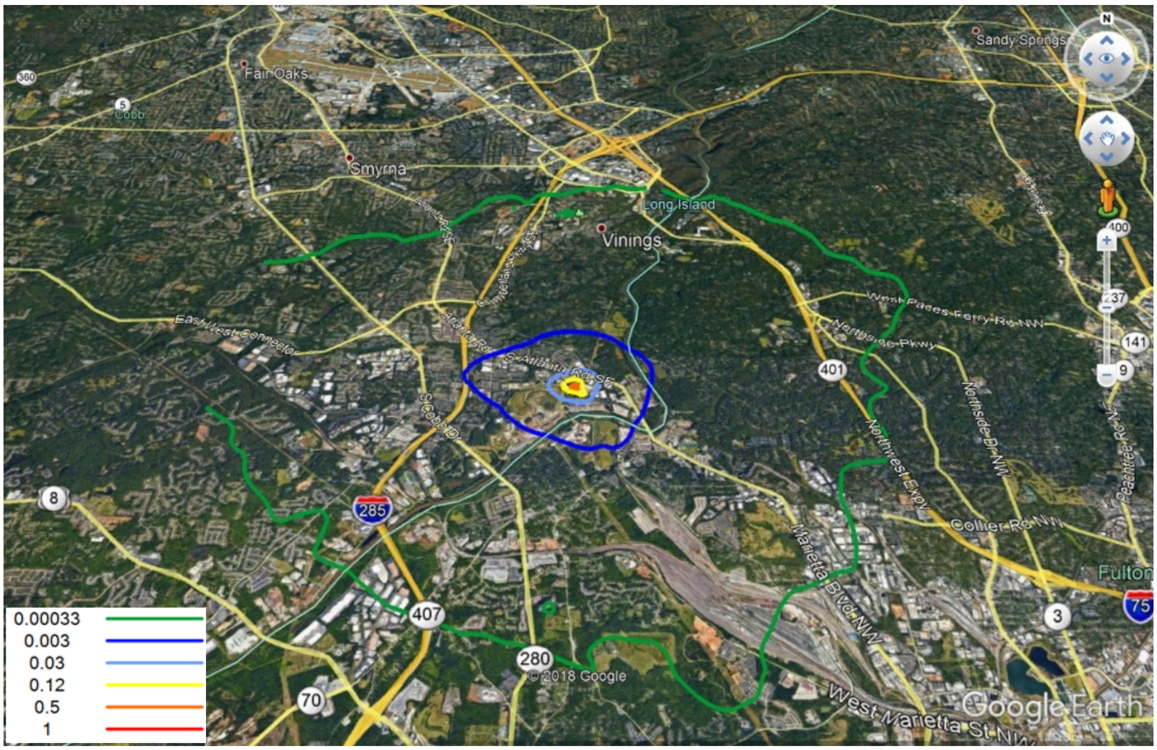

Figure 5. Contours of 5-year annual average ground-level concentrations modeled with the current emission scenario overlaid on a Google Earth map.

Figure 6. Contours of 5-year annual average ground-level concentrations modeled with the proposed emission scenario overlaid on a Google Earth map.

Figure 7. A close-up look of Figure 5 with the closest residential areas labeled.

Figure 8. A close-up look of Figure 6 with the closest residential areas labeled.

Table 4. Risk Analysis for Residential Areas with 5-year Average Ground-level Concentrations.

Residential Areas	Receptor UTM Zone:16		Ground-level Concentration (μg/m^3)		Averaging Period	AAC (μg/m^3)	Ratio of Ground-level Concentration (μg/m^3) to AAC (μg/m^3)	
	Easting (meter)	Northing (meter)	Current Scenario	Proposed Scenario			Current Scenario	Proposed Scenario
R1	734,456.40	3,746,827.10	0.020	0.007	Annual	0.00033	61	21
R2	734,349.30	3,746,923.70	0.015	0.006	Annual	0.00033	45	18
R3	734,073.40	3,746,829.10	0.017	0.006	Annual	0.00033	52	18
R4	733,449.70	3,746,572.40	0.009	0.005	Annual	0.00033	27	15

CONCLUSIONS

The dispersion modeling analysis for ethylene oxide shows exceedances at the annual AAC level with the current and proposed emission scenarios. The risk assessment with the current emission scenario indicates that residential areas are well above the AAC level (27-61 times). The risk at residential areas is reduced by approximately 50% with the proposed scenario, but the modeled impacts are still well above the AAC (12-24 times).

Appendix A

Current Emissions and Model Input Parameters

Ethylene Oxide (EtO) Emissions

Emission Source	2017 EtO Emissions (lb/yr)
AAT Scrubber	13.72
Ceilcote Scrubber	3.98
Fugitives	188.39

Model Input Parameters for EtO Emissions Sources

Model ID	Stack Description	Source Type	UTM E[1] (m)	UTM N[1] (m)	Elevation[2] (m)	Modeled EtO Emissions[3] (g/s)	Stack Height		Stack Temperature		Exhaust Gas Flow Rate (cfm)	Exit Velocity		Stack Diameter	
							(ft)	(m)	(°F)	(K)		(ft/s)	(m/s)	(ft)	(m)
STK1	AAT Scrubber	POINT	734,253.6	3,746,381.0	251.59	1.97E-04	51.0	15.54	98	309.82	12,000	46.8	14.256	2.3	0.71
STK2	Ceilcote	POINT	734,232.1	3,746,355.7	250.08	5.72E-05	51.0	15.54	85	302.59	2,000	42.4	12.936	1.0	0.30
STK3	Roof Fan	POINT	734,267.9	3,746,355.2	251.21	6.02E-04	29.0	8.84	75	297.04	16,000	37.7	11.499	3.0	0.91
STK4	Roof Fan	POINT	734,256.7	3,746,361.0	251.07	6.02E-04	29.0	8.84	75	297.04	16,000	37.7	11.499	3.0	0.91
STK5	Wall Fan	POINTHOR	734,226.1	3,746,349.0	249.61	-	20.0	6.10	75	297.04	200	0.8	0.254	2.3	0.69
STK6	Wall Fan	POINTHOR	734,211.5	3,746,357.1	249.46	-	23.0	7.01	75	297.04	6,000	25.0	7.620	2.3	0.69
STK7	Wall Fan	POINTHOR	734,201.8	3,746,366.6	249.67	-	23.0	7.01	75	297.04	6,000	25.0	7.620	2.3	0.69
STK8	Wall Fan	POINTHOR	734,180.6	3,746,413.3	250.46	1.51E-04	4.8	1.47	75	297.04	5,985	21.3	6.477	2.4	0.75
STK9	Wall Fan	POINTHOR	734,189.0	3,746,420.2	250.93	1.51E-04	12.5	3.81	75	297.04	2,122	6.3	1.930	2.7	0.81
STK10	Wall Fan	POINTHOR	734,197.7	3,746,427.9	251.32	6.02E-04	13.5	4.11	75	297.04	409	20.7	6.299	0.6	0.20
STK11	Wall Fan	POINTHOR	734,201.8	3,746,431.4	251.61	6.02E-04	13.8	4.22	75	297.04	1,031	52.1	15.875	0.6	0.20
STK12	Wall Fan	POINTHOR	734,210.2	3,746,438.3	252.02	-	20.0	6.10	75	297.04	20,000	15.9	4.836	5.2	1.58

Notes:

1. Coordinates reflect UTM NAD83, Zone 16.
2. Modeled elevations were incorporated using AERMAP. Terrain elevation data was obtained using the National Elevation Data (NED) files from the USGS Multi-Resolution Land Characteristics Consortium (MRLC).
3. Smoke testing conducted at the Atlanta facility has shown there are no EtO emissions released from the wall fans associated with STK5 through STK7 and from STK12.

Appendix B

Proposed Emissions and Model Input Parameters

Ethylene Oxide (EtO) Emissions

Emission Source	2017 EtO Emissions (lb/yr)
AAT Scrubber	13.72
Ceilcote Scrubber	3.98
Fugitives	188.39

Model Input Parameters for EtO Emissions Sources

Model ID	Stack Description	Source Type	UTM E[1] (m)	UTM N[1] (m)	Elevation[2] (m)	Modeled EtO Emissions[3] (g/s)	Stack Height		Stack Temperature		Exhau Flow (cf
							(ft)	(m)	(°F)	(K)	
STK1	AAT Scrubber	POINT	734,253.6	3,746,381.0	251.59	1.97E-04	51.0	15.54	98	309.82	12,0
STK2	Ceilcote	POINT	734,232.1	3,746,355.7	250.08	5.72E-05	51.0	15.54	85	302.59	2,0
STK3	Roof Fan	POINT	734,267.9	3,746,355.2	251.21	6.02E-04	29.0	8.84	75	297.04	16,0
STK4	Roof Fan	POINT	734,256.7	3,746,361.0	251.07	6.02E-04	29.0	8.84	75	297.04	16,0
STK5	Wall Fan	POINTHOR	734,226.1	3,746,349.0	249.61	-	20.0	6.10	75	297.04	20
STK6	Wall Fan	POINTHOR	734,211.5	3,746,357.1	249.46	-	23.0	7.01	75	297.04	6,0
STK7	Wall Fan	POINTHOR	734,201.8	3,746,366.6	249.67	-	23.0	7.01	75	297.04	6,0
STK812A	Roof Stack A for Fugitive Emissions	POINT	734,206.0	3,746,414.0	251.18	7.53E-04	105.0	32.00	75	297.04	7,5
STK812B	Roof Stack B for Fugitive Emissions	POINT	734,197.0	3,746,410.0	250.80	7.53E-04	105.0	32.00	75	297.04	7,5

Notes:

1. Coordinates reflect UTM NAD83, Zone 16.
2. Modeled elevations were incorporated using AERMAP. Terrain elevation data was obtained using the National Elevation Data (NED) files from the USGS Multi-Resolution Land Characteristics Consortium (MRLC).
3. Smoke testing conducted at the Atlanta facility has shown there are no EtO emissions released from the wall fans associated with STK5 through STK7.

Appendix C

GA EPD Calculation of the Annual and 15-min AAC for Ethylene Oxide

GA EPD Calculation of the Annual and 15-min AAC for Ethylene Oxide

According to the GA EPD's *Guideline for Ambient Impact Assessment of Toxic Air Pollutant Emissions*, the annual and 15-min AAC for ethylene oxide are calculated as following:

Annual AAC

In the EPA Integrated Risk Information System (IRIS)[2], the Inhalation Unit Risk (IUR) for ethylene oxide is 3×10^{-3} per $\mu g/m^3$. Since ethylene oxide is carcinogenic to humans, it belongs to Group A[3] with a cancer risk of 1/1,000,000. Therefore, the annual AAC is calculated as:

$$\text{Annual AAC} = \text{Cancer Risk} / \text{IUR} = (1/1{,}000{,}000)/(0.003/\mu g/m^3) = \mathbf{0.00033\ \mu g/m^3}$$

15-min AAC

The OSHA permissible exposure limit (PEL) for ethylene oxide is 5 ppm. To convert the PEL from ppm to mg/m^3, use the following conversion formula from the guidance:

$$(5\text{ ppm} \times 44.05\text{ g/mol}) / (24.45\text{ L/mol}) = 9\text{ mg/m}^3$$

where, 44.05 is the molecular weight for ethylene oxide and 24.45 is the molar volume at 25°C and 760 mmHg. After applying a safety factor of 10 for acute sensory irritants, the 15-min AAC is calculated as:

$$\text{15-min AAC} = 9\text{ mg/m}^3 \times 1000\text{ (convert mg to }\mu g) / 10\text{ (safety factor)} = \mathbf{900\ \mu g/m^3}$$

2 https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/1025_summary.pdf

3 https://www.epa.gov/fera/risk-assessment-carcinogenic-effects

Appendix D

EPA Calculation of the Annual AAC
for Ethylene Oxide

EPA Calculation of the Annual AAC for Ethylene Oxide

According to EPA's IRIS, inhalation unit risk (IUR) for ethylene oxide (EtO) is 3×10^{-3} per $\mu g/m^3$ (as discussed in Appendix C). However, because of the elevated risk due to the mutagenic mode of action through early-life exposures, EPA multiplied the IUR by 1.6:

Modified IUR for EtO = 3×10^{-3} per $\mu g/m^3$ x 1.6 = $0.005/\mu g/m^3$

EPA's NATA used (100/1,000,000) individual risk for the purpose of determining "acceptable risk" (AR) in their national assessment.

AR Exposure Concentration = Cancer Risk / IUR = $(100/1{,}000{,}000)/(0.005/\mu g/m^3)$ **= 0.02 $\mu g/m^3$**

However, EPA uses (1/1,000,000) individual risk to incorporate an "ample margin of safety" (AMS) for setting emission standards[4] (e.g., benzene NESHAP).

AMS Exposure Concentration = Cancer Risk / IUR = $(1/1{,}000{,}000)/(0.005/\mu g/m^3)$ **= 0.0002 $\mu g/m^3$**

4 https://www3.epa.gov/ttn/atw/rrisk/risk_rep.pdf